UNCONTROLLED

WEST VALLEY NUCLEAR SERVICES CO., INC.

ANALYTICAL CHEMISTRY METHOD
ANALYTICAL AND PROCESS CHEMISTRY

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CONDUCTIVITY

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Part I

1.0 PURPOSE

This method will be used to test an aqueous sample for conductivity.

2.0 APPLICATION

Conductivity may be measured in most aqueous samples to assess the degree of mineralization in distilled water and aqueous samples. Conductivity can be measured from a few µmhos to hundreds of µmhos .

3.0 DISCUSSION

3.1 Conductivity is defined as the ability of a substance to conduct electric current. It is the reciprocal of resistivity. All substances possess conductivity to some degree, but the amount varies widely, ranging from extremely low (insulators such as benzene and glass) to very high (silver, copper, and metals in general). Most interest is in measuring the conductivity of liquids, which generally consist of ionic compounds dissolved in water. This conductivity can be measured quite easily by electronic means, and this offers a simple test which can tell much about the quality of water, or the make-up of a solution.

3.2 TEMPERATURE EFFECTS

The conduction process in aqueous solutions is by means of ionic motion, and is different from that of metals. The conductivity invariable increases with increasing temperature. It is affected by the nature of the ions, and by the viscosity of the water. In low ionic concentrations (very pure water), the ionization of the water furnishes an appreciable part of the conducting ions.

All these processes are quite temperature dependent, and as a result, the conductivity has a substantial dependence on temperature. This dependency is usually expressed a relative change per degree Celsius at a particular temperature, commonly as percent/°C at 25°C, and this is called the slope of the solution. Ultrapure water has by far the largest slope, 5.2 percent/°C, while ionic salts run about 2 percent/°C in the middle ranges. Acids, alkalis and concentrated salt solutions run somewhat lower, typically 1.5 percent/°C. From these figures, it is obvious that a small difference in temperature makes a large difference in conductivity, and the effect is very troublesome when a high degree of accuracy is required. In making conductivity readings at high and low temperature, the data is usually normalized to 25°C, i.e., it is stated as what the reading is with a 25°C solution.

In general, the most accurate results occur when the excursions around the normal operating temperature are small, or when operation is at or near room temperature. The variation of conductivity due to temperature frequently gives problems when the solution under test has a rapidly varying temperature. The change in conductivity measurement is instantaneous, since this is an electrical measurement. Fortunately, most process streams and vessels have large thermal mass and cannot change temperature rapidly.

3.3 Definitions

3.3.1 Electrical Conductivity - The reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a specific temperature.

3.3.2 Electrical Resistivity - The resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a specific temperature.

4.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 16th edition, 1988 Method 205, p. 77.

Part II

5.0 EQUIPMENT

NOTE: All equipment is controlled and calibrated per ACP 7.1.

> 5.1 Beckman Model RC-20 Conductivity Bridge

5.1.1 Conductivity Cell -- Beckman G-100

> 5.1.2 Automatic Temperature Compensating Probe

> 5.2 Myron L Company EP Meter

6.0 REAGENTS AND STANDARDS

6.1 ASTM type II water

> 6.2 Biopharm (Product No. BC 4095, 200 μmho/cm at 25°C) and YSI (Product No. 3165, 100,000 μmho/cm at 25°C) conductivity standards. These standards have a shelf life indicated on the container. No special storage requirements are needed.

> 6.2.1 After opening, discard the standard in six months or at manufacturers specification.

7.0 SAFETY

Standard laboratory safety precautions should be used.

See ACP 7.2.

8.0 RECORDS

All measurements shall be recorded on the worksheet attachment A. The final results shall be recorded on the analytical request sheet (ACP 5.1).

9.0 CALIBRATION AND CONTROL

> 9.1 Beckman Model RC-20 Conductivity Bridge.

9.1.1 TEST CONNECTIONS

Connect the conductivity cell or the unknown resistance to the binding posts marked "2" and "3". See the instruction manual for the occasional measurement where an external capacitor is required between binding posts "1" and "2" to correct for phase differences in the bridge arms.

9.1.2 BRIDGE FREQUENCY

Bridge frequency of either 85 Hz or 1000 Hz can be selected by means of a toggle switch located in the upper left hand section of the instrument panel. Generally, the lower frequency should be used when the measured resistance is high, and the higher frequency used when the measured resistance is low.

9.1.3 INSTRUMENT OPERATION

a. The instrument is turned on by actuating the toggle switch located in the upper left hand section of the panel labeled ON-BAT CHECK. A momentary actuation of the ON position will activate the instrument for approximately 5 minutes. At the end of the five minutes interval, the instrument will automatically switch itself off and the front panel meter will return to the OFF position.

b. Set panel controls as follows:

Frequency	85 or 1000 Hz
Capacitance, Coarse & fine	Zero
Mode	Cond./Res.
Multiplier	1" on Resistance or "0.1" on Conductance Range
Counter Window	1.05
Temperature Compensator Selector	None

c. Rotate the Multiplier Dial step by step through is (conductivity or resistance) ranges starting at lowest multiplier value until the meter pointer passes through the "0" (zero) mark. Step multiplier dial back one step so the melter deflects to the left. Turn Counter Dial clockwise until the meter reads zero.

When the meter reading zero, place the Mode Switch in the CAP position and observe the meter deflection. If the deflection is less than one major division (equal to five minor divisions) either side of zero no further balance adjustment is necessary. The measured resistance or conductance is determined from the Counter window indication and multiplier switch setting as described in paragraphs 9.1.4 and 9.1.5 below.

. If the meter deflection is greater than one major division turn the FINE CAPACITANCE switch knob clockwise step by step to bring the meter deflection to zero. If the FINE CAPACITANCE produces only small meter deflection changes set this control to zero and advance the COARSE CAPACITANCE CONTROL clockwise step by step until meter deflection approaches zero. In most cases adjustment of both COARSE AND FINE CAPACITANCES will give deflections close to zero well within the required one major division.

Alternating the Mode Switch between CAP, and COND./RES. adjust the appropriate controls according to the above procedure until a zero reading is obtained on COND./RES. and within at most one major division of zero on CAP. The bridge balance is now complete.

See the instruction manual for more detailed instructions and for the use of the manual and automatic compensator positions of the temperature compensator selector.

9.1.4 DETERMINATION OF RESISTANCE

The measured resistance in ohms of resistor or conductivity cell connected between binding posts "2" and "3" is found by multiplying the reading in ohms taken from the counter window by the corresponding multiplier from the resistance multiplier scale.

The specific resistance (resistivity) of an electrolyte in ohm-cm is found by dividing the measured resistance in ohms (above) by the cell constant in cm^{-1}.

9.1.5 DETERMINATION OF CONDUCTANCE

The measured conductance in micromhos (microsiemen's) of a resistor or conductivity cell connected between binding posts 2 and 3 is found by multiplying the reading in micromhos taken from the counter window by the corresponding multiplier from the conductance multiplier scale.

The specific conductance (conductivity) of an electrolyte in micromhos/cm is found by multiplying the measured conductance (above) by the cell constant in cm^{-1}.

The conductivity (specific conductance) = Cell constant x dial readout x conductivity multiplier.

Ex. If G-100 cell constant is 100, conductivity multiplier is 1000, and the dial readout is 2.42, the conductivity = 242,000 micromhos.

9.1.6 BATTERY CHECK

With the instrument operating, push the BATTERY CHECK switch and observe the meter reading, Any reading to the right of the "BAT" line indicates the battery is good. A reading to the left of the "BAT" line indicates the batteries should be replaced, or if equipped with Nickel-Cadmium batteries, recharged. The instrument can be used to measure ungrounded solutions while the batteries are being recharged. Replace Carbon-Zinc batteries with standard "C" size batteries. The Nickel-Cadmium batteries should be charged only from the battery charger supplied with the instrument.

> 9.2 Myron L Company EP Meter

> 9.2.1 CHECKING CALIBRATION

> a. Turn the range switch to the x1000 range and test with the Biopharm Conductivity Standard Solution. Throw the standard solution away as it is used. Do not put the used samples back in the bottle.

> b. If the meter does not indicate the same value as is on the standard solution bottles label, clean the cell as described in step 9.2.3b. Rinse the cell thoroughly and test the Standard Solution again. If the meter still does not indicate the correct value, recalibrate it as described in step 9.2.2.

> 9.2.2 RECALIBRATION

> a. Remove the bottom cover using a small screwdriver to loosen the front or read edge. Identify the calibration control so that it can be found by touch while calibrating.

> b. Test another sample of the Standard Solution while avoiding any splashing of solution inside of the meter. Adjust the calibration control until the meter indicates the value that is on the Standard Solution label.

> 9.2.3 MAINTENANCE

> a. Model EP has a battery indicator glow light visible through the small hole on the lower right-hand corner of the meter fuse plate. If this light fails to glow when the black button is pressed, replace both batteries with fresh zinc carbon or alkaline 9 volt batteries.

\> b. When there are visible films of oil, dirt, or scale in the cell cup or on the electrodes, scrub them lightly with a small brush and household cleaner. Rinse after cleaning.

\> 9.2.4 TEMPERATURE COMPENSATION

\> For very hot or cold solutions, let the three rinse samples each remain in the cell for several seconds, then immediately fill the cell with the sample to be tested. This allows the automatic temperature compensation feature time to work properly.

\> 9.3 A quality control log book and control charts will be used to record all the standard checks. Calibration of equipment shall be done on each work day before the daily check of the nano-pure water (ASTM type II), and any samples are to be analyzed.

10.0 PROCEDURE

\> 10.1 Beckman Model RC-20 Conductivity Bridge

10.1.1 Rinse cell with two or more portions of the first standard.

10.1.2 Fill the cell with the third portion of the standard and read the result from the meter with the temperature compensator dial in the "NONE" mode. Record the temperature of the standard from a thermometer measuring the ambient room temperature which will be the temperature of the standard.

10.1.3 As an alternate method to calibrating with these standards, use the 100,000 μmho at 25°C and read this standard at the ambient temperature. Determine the ratio of conductivity (conductivity at ambient temperature/100,000 μmhos at 25°C) of the standard. When the sample is measured at this same temperature, divide this conductivity of the sample at ambient temperature by the conductivity ratio in order to obtain the conductivity of the sample at 25°C.

10.1.4 Repeat steps 10.1 and 10.2 for the other standards, if necessary.

10.1.5 Repeat steps 10.1 and 10.2 for the sample.

\> 10.2 Myron L Company EP Meter

\> 10.2.1 Turn the range switch to the desired range.

> 10.2.2 Rinse the cell three times with the standard to be tested then fill the cell to at least 1/4 inch above the upper electrode. Press the black button. Read the dial's black scale value indicated by the pointer. Adjust range if necessary. Rinse the cell clean.

> 10.2.3 Repeat steps 10.2.1 and 10.2.2 for the sample.

11.0 CALCULATIONS

> Both conductivity meters are calibrated in μmhos and are read directly. For the RC-20 only, however, the conductivity of the sample is obtained directly by reading the meter scale times the multiplier times the cell constant.

12.0 ATTACHMENT

Attachment A - Conductivity Worksheet.

> ATTACHMENT A

CONDUCTIVITY WORKSHEET

SAMPLE NAME ______________________ LOG NUMBER ______________

SPECIAL INSTRUCTIONS ______________________________________

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>Instrument (Model and Serial #): ___________________________

SAMPLE ID				
TEMPERATURE				
STANDARD #1				
STANDARD #2				
STANDARD #3				
SAMPLE				
SAMPLE AT 25°C				

ANALYST ______________________ DATE ______________

APPROVED _____________________ DATE ______________